US009338192B1

(12) **United States Patent**
He et al.

(10) **Patent No.: US 9,338,192 B1**
(45) **Date of Patent: May 10, 2016**

(54) **CONNECTION MANAGEMENT USING CONNECTION REQUEST TRANSFER PROTOCOL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 411 days.

(21) Appl. No.: **13/730,023**

(22) Filed: **Dec. 28, 2012**

(51) **Int. Cl.**
G06F 15/16 (2006.01)
H04L 29/06 (2006.01)
H04L 29/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 65/1069*** (2013.01); ***H04L 67/28*** (2013.01); ***H04L 69/16*** (2013.01); ***H04L 69/165*** (2013.01)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,711,956 B2 * 5/2010 Kinoshita et al. 713/168
2008/0177829 A1 * 7/2008 Banerjee et al. 709/203
2009/0132714 A1 * 5/2009 Blander et al. 709/227
2009/0177788 A1 * 7/2009 Ishikawa et al. 709/228
2012/0239775 A1 * 9/2012 Hubbard et al. 709/217
2012/0271905 A1 * 10/2012 Issa 709/213
2014/0122580 A1 * 5/2014 Nuaimi et al. 709/203

* cited by examiner

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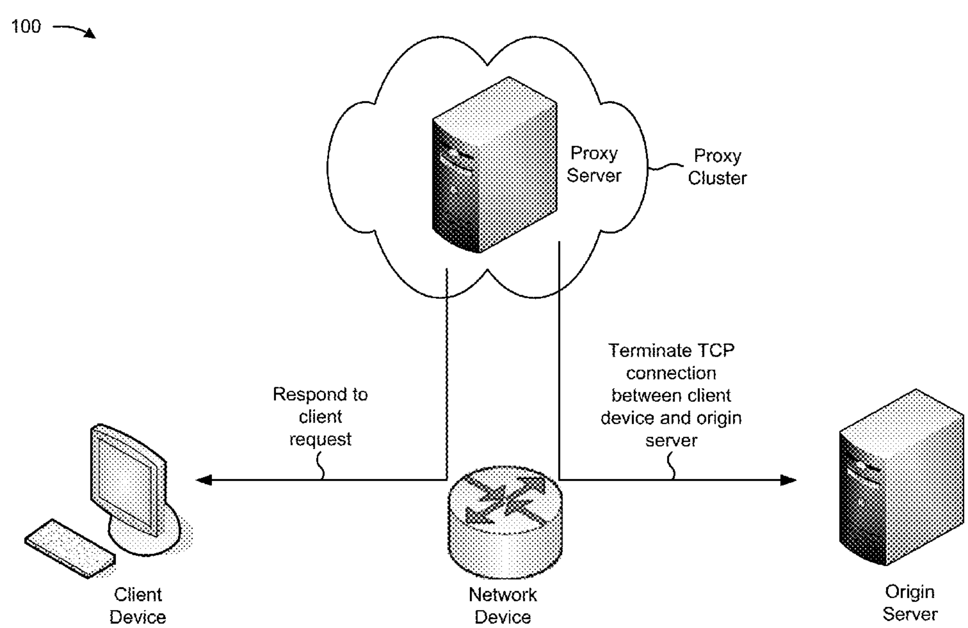
(57) **ABSTRACT**

A network device receives, from a client device, a client request associated with a connection with a server device, where the client request identifies requested content. The network device determines connection information that identifies the connection with the server device, transmits, to a proxy server, a connection transfer request that identifies the connection information and the requested content, and receives, from the proxy server, an indication that the proxy server is capable of providing the requested content. Based on receiving the indication, the network device provides, from the proxy server to the client device, a response to the client request, and provides, from the proxy server and to the server device, information that causes the server device to terminate the connection. The network device may use a connection request transfer protocol to transmit the connection transfer request, and the client request may be an HTTP request.

20 Claims, 13 Drawing Sheets



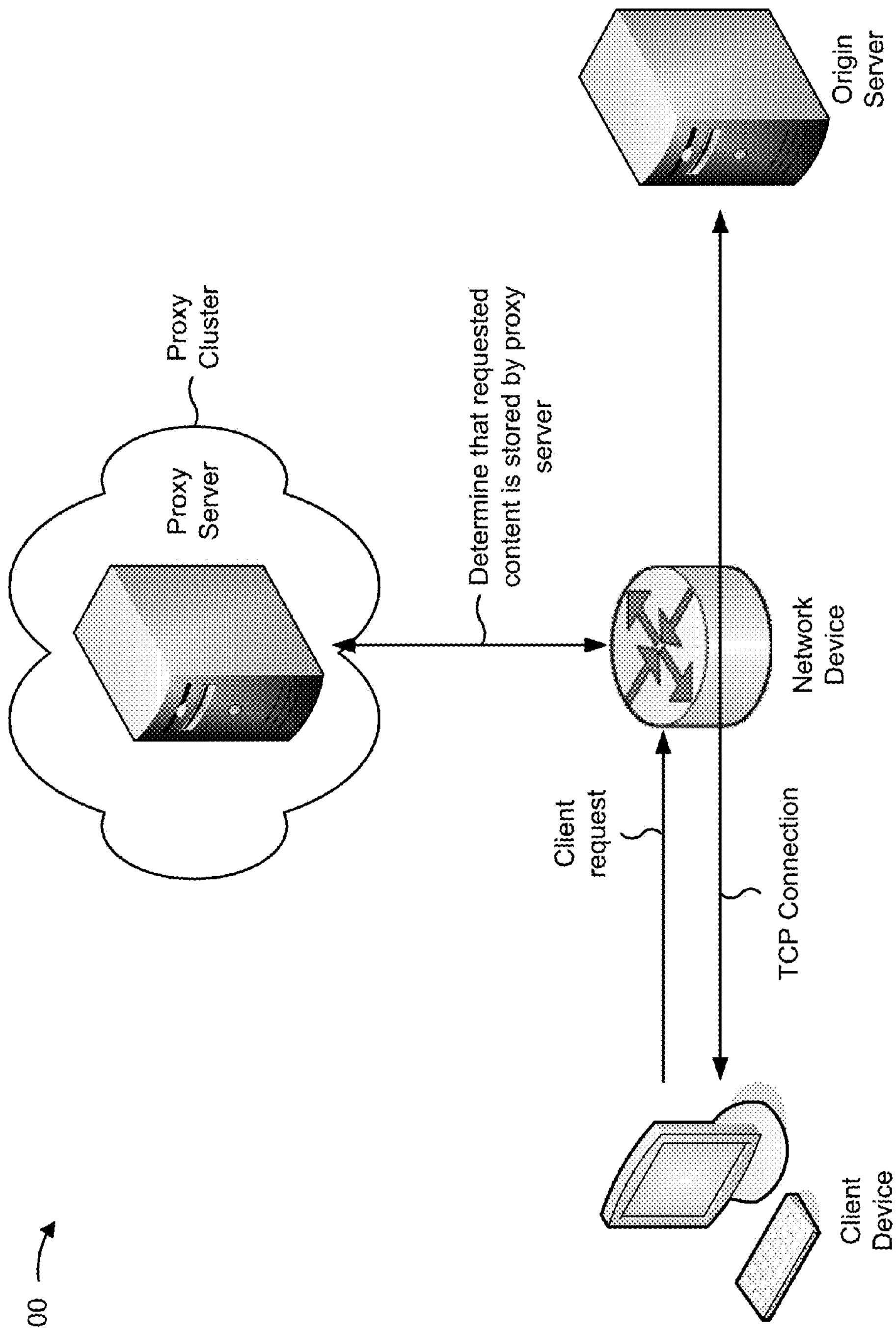

100
Proxy Cluster
Proxy Server
Determine that requested content is stored by proxy server
Origin Server
Network Device
Client request
TCP Connection
Client Device

FIG. 1A

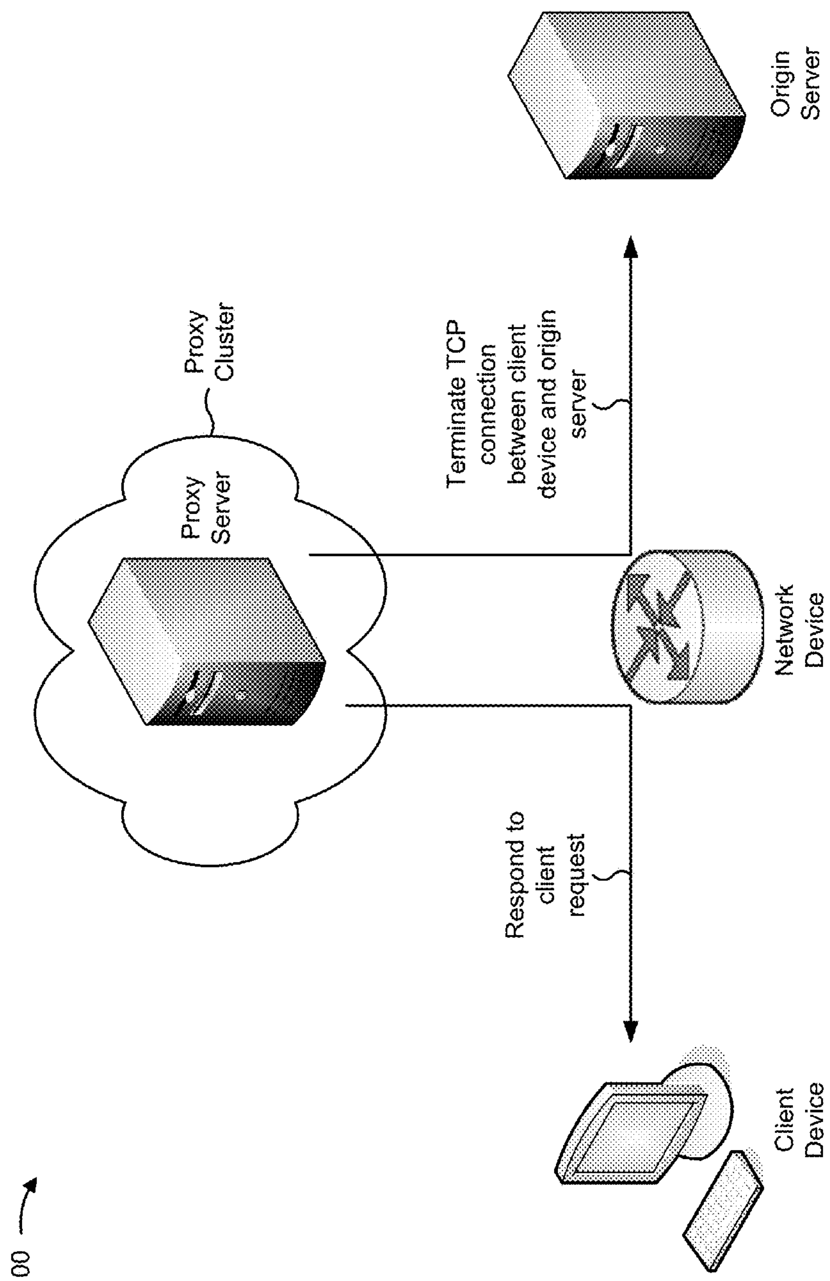

100
Proxy Cluster
Proxy Server
Terminate TCP connection between client device and origin server
Origin Server
Network Device
Respond to client request
Client Device

FIG. 1B

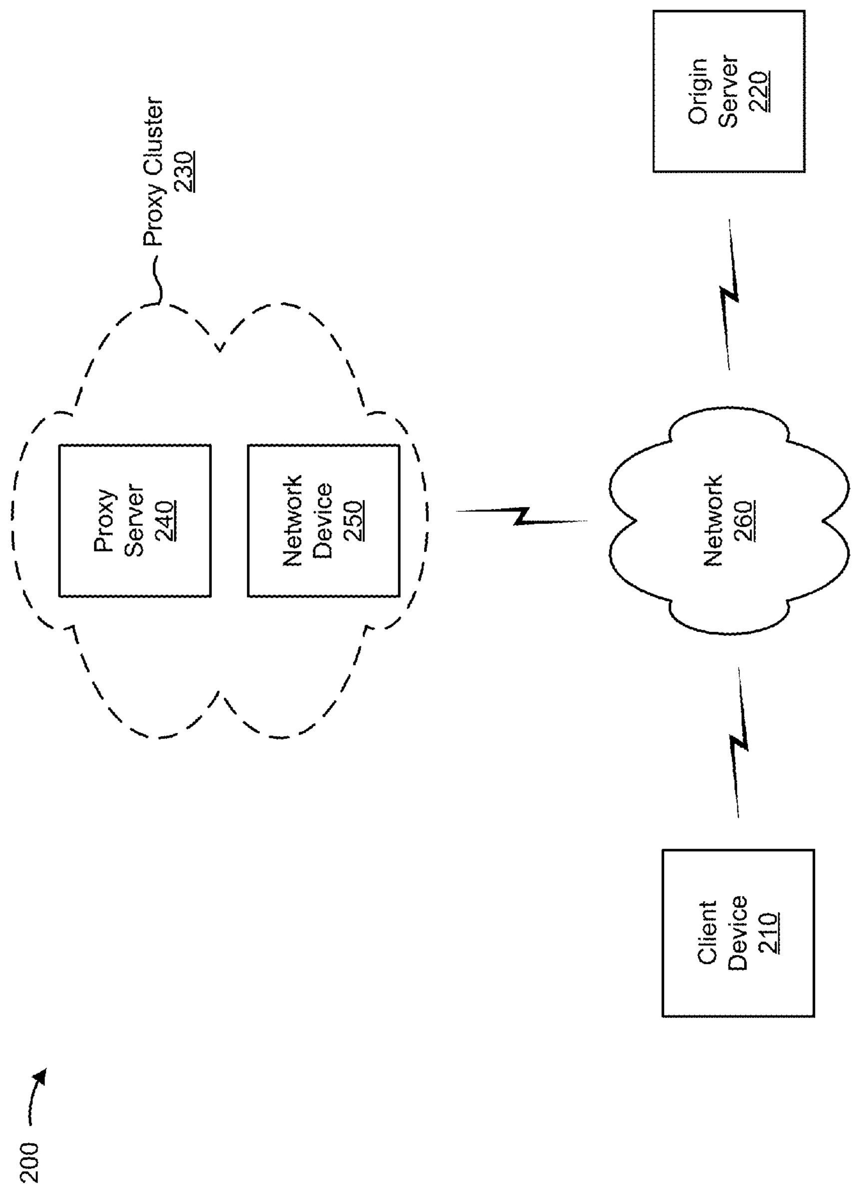

Proxy Cluster
230
Proxy
Server
240
Network
Device
250
Network
260
Origin
Server
220
Client
Device
210
200

FIG. 2

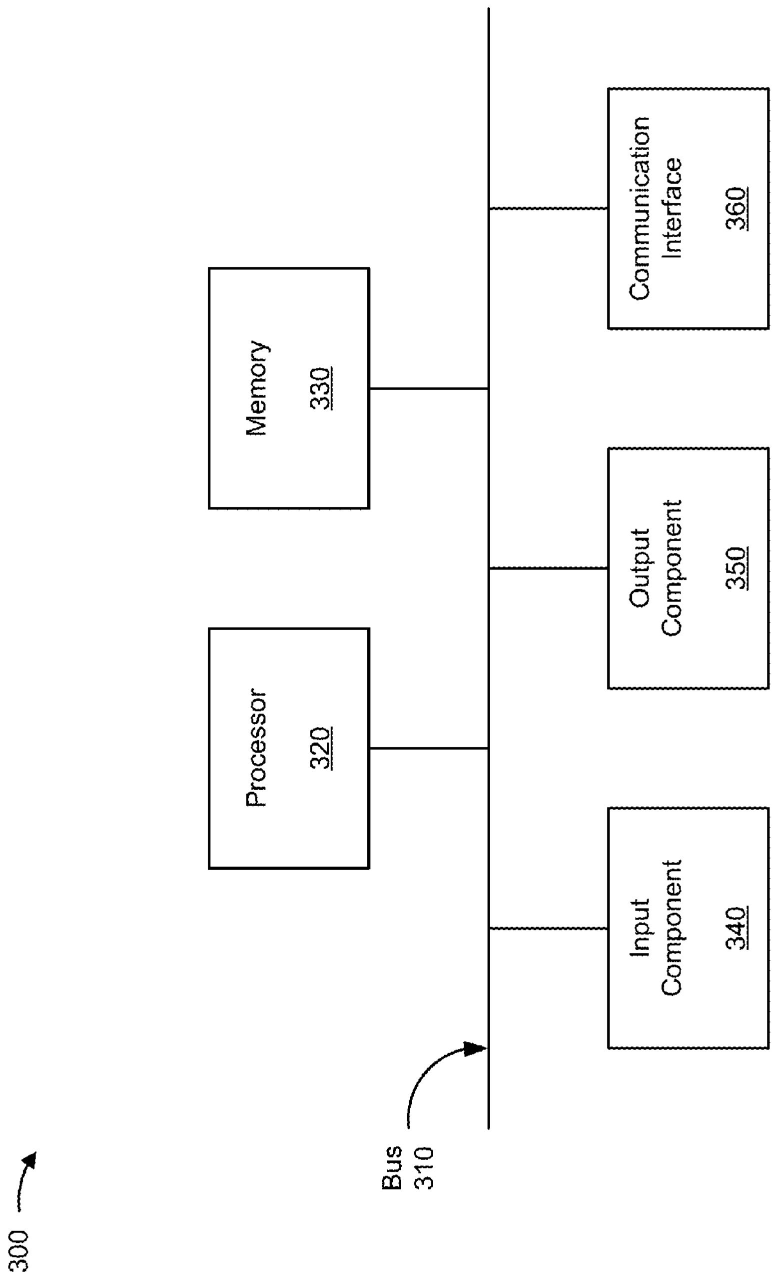

300
Bus
310
Processor
320
Memory
330
Input
Component
340
Output
Component
350
Communication
Interface
360

FIG. 3

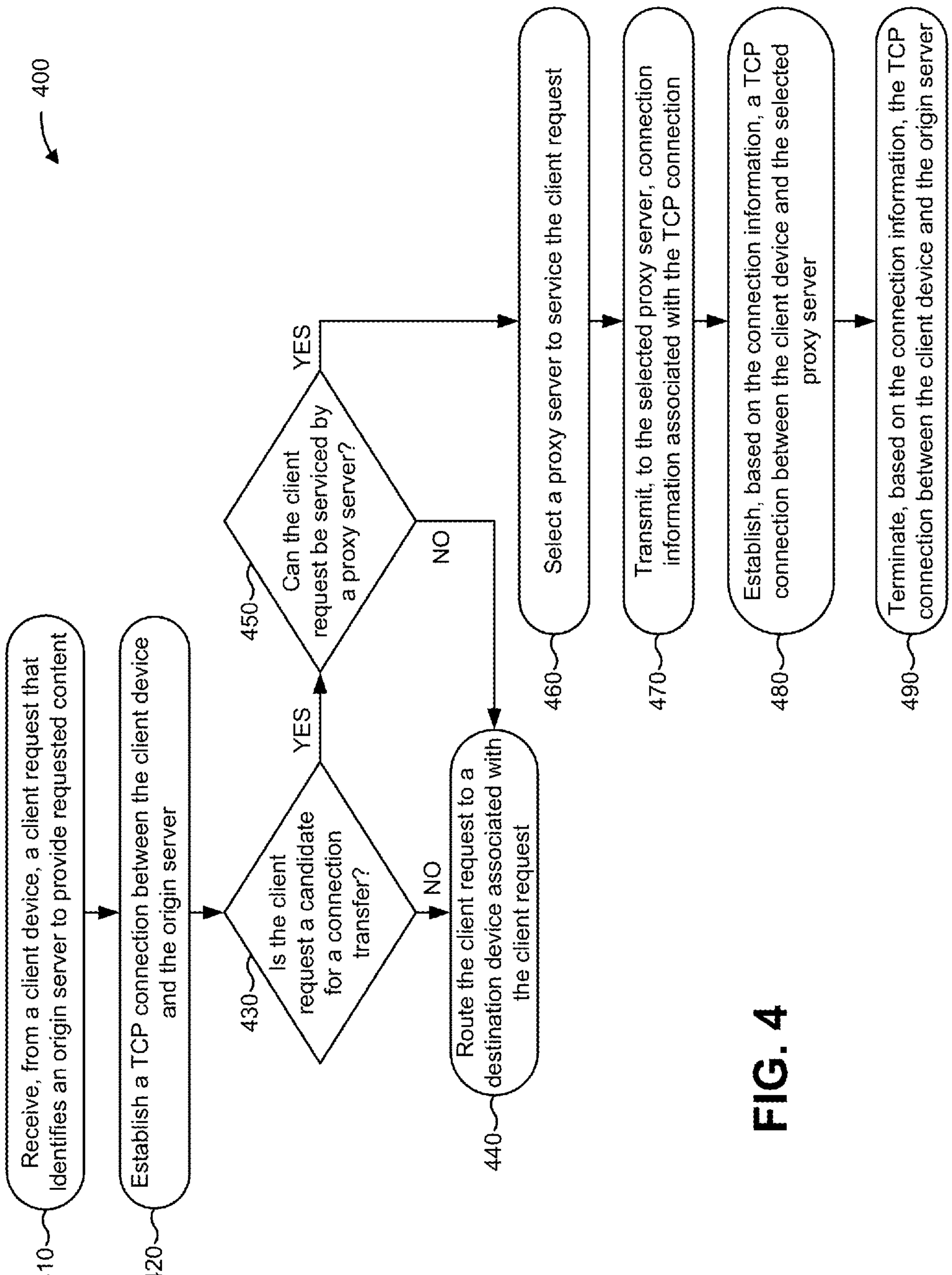

400
410
Receive, from a client device, a client request that identifies an origin server to provide requested content
420
Establish a TCP connection between the client device and the origin server
430
Is the client request a candidate for a connection transfer?
YES
NO
440
Route the client request to a destination device associated with the client request
450
Can the client request be serviced by a proxy server?
YES
NO
460
Select a proxy server to service the client request
470
Transmit, to the selected proxy server, connection information associated with the TCP connection
480
Establish, based on the connection information, a TCP connection between the client device and the selected proxy server
490
Terminate, based on the connection information, the TCP connection between the client device and the origin server

FIG. 4

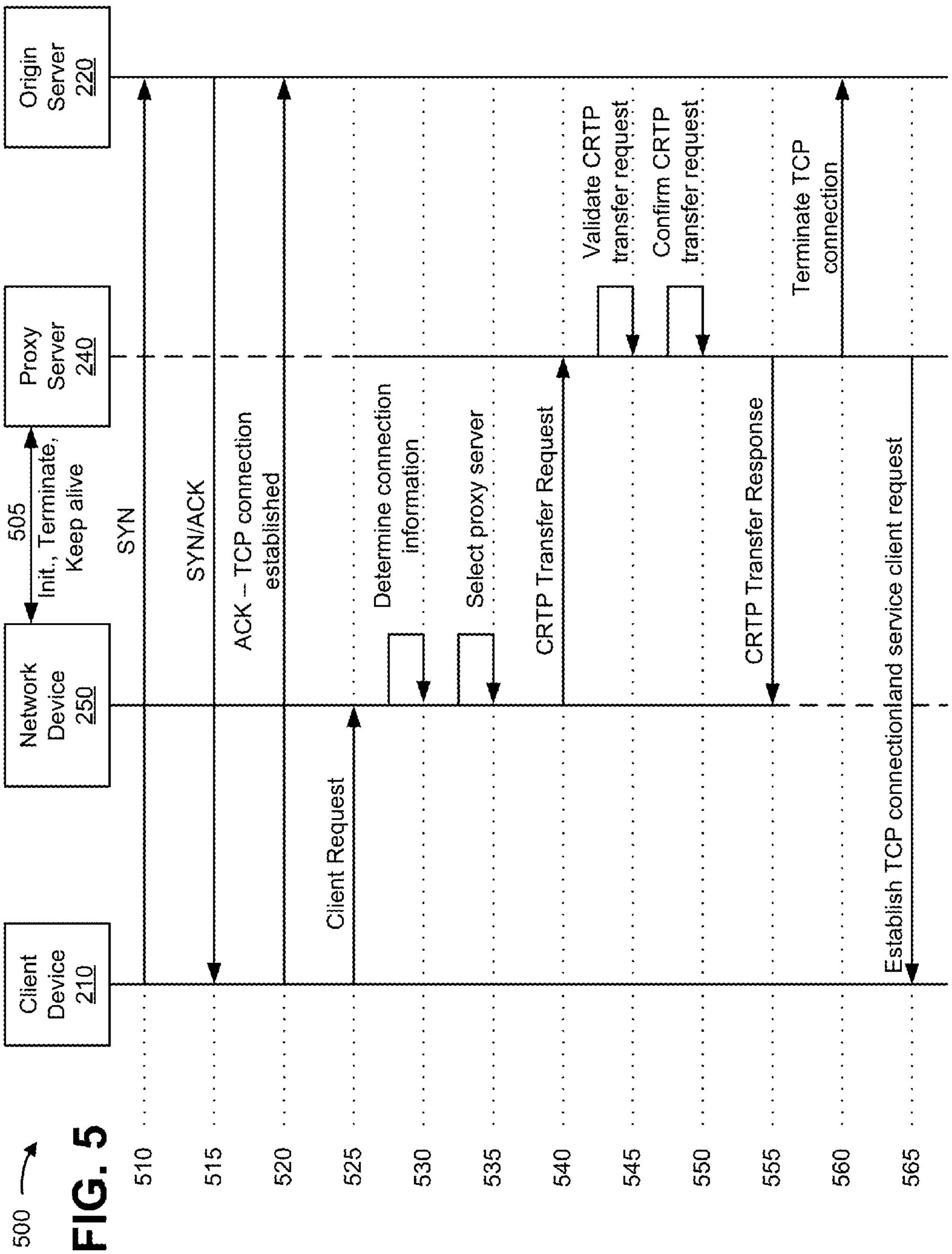
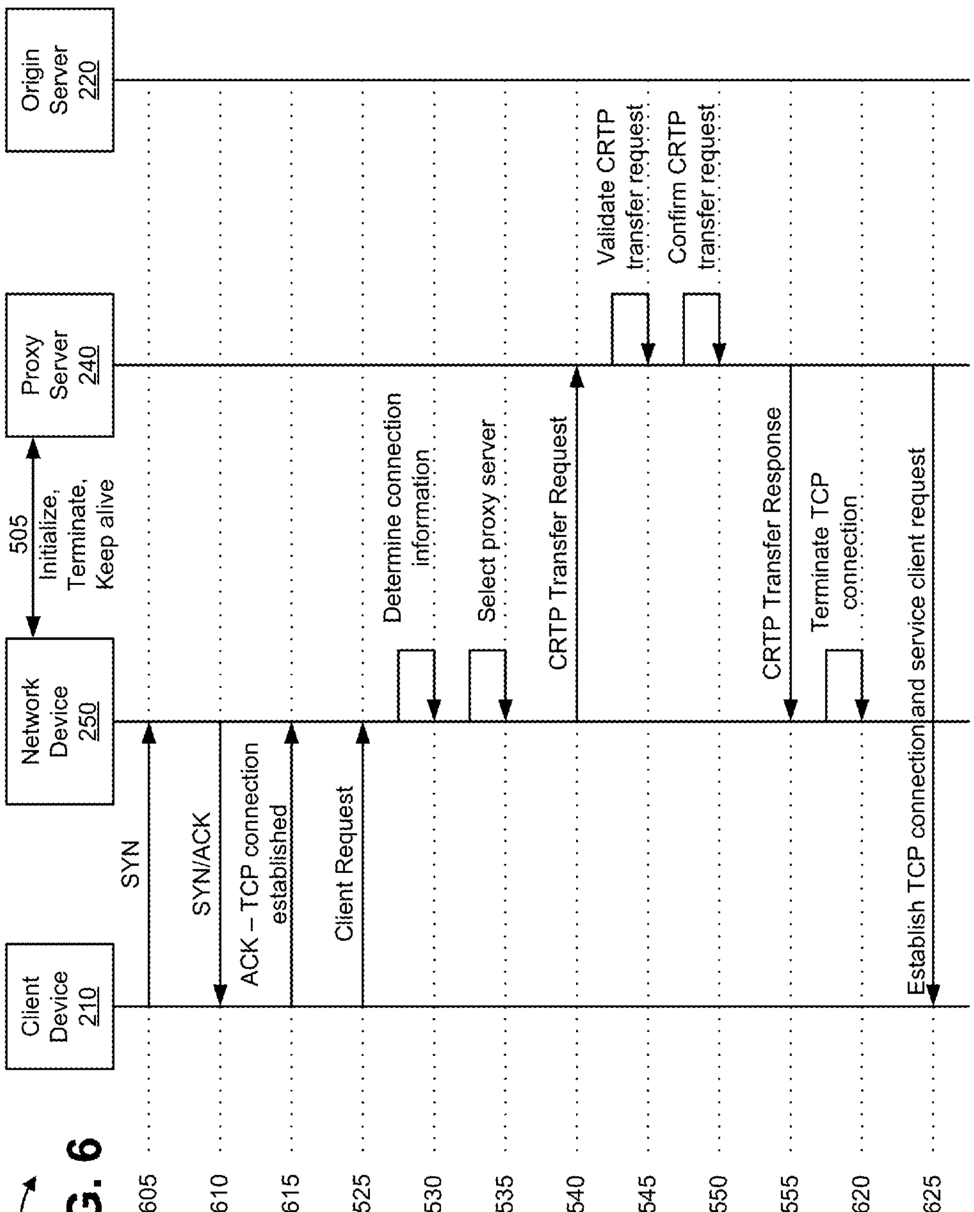
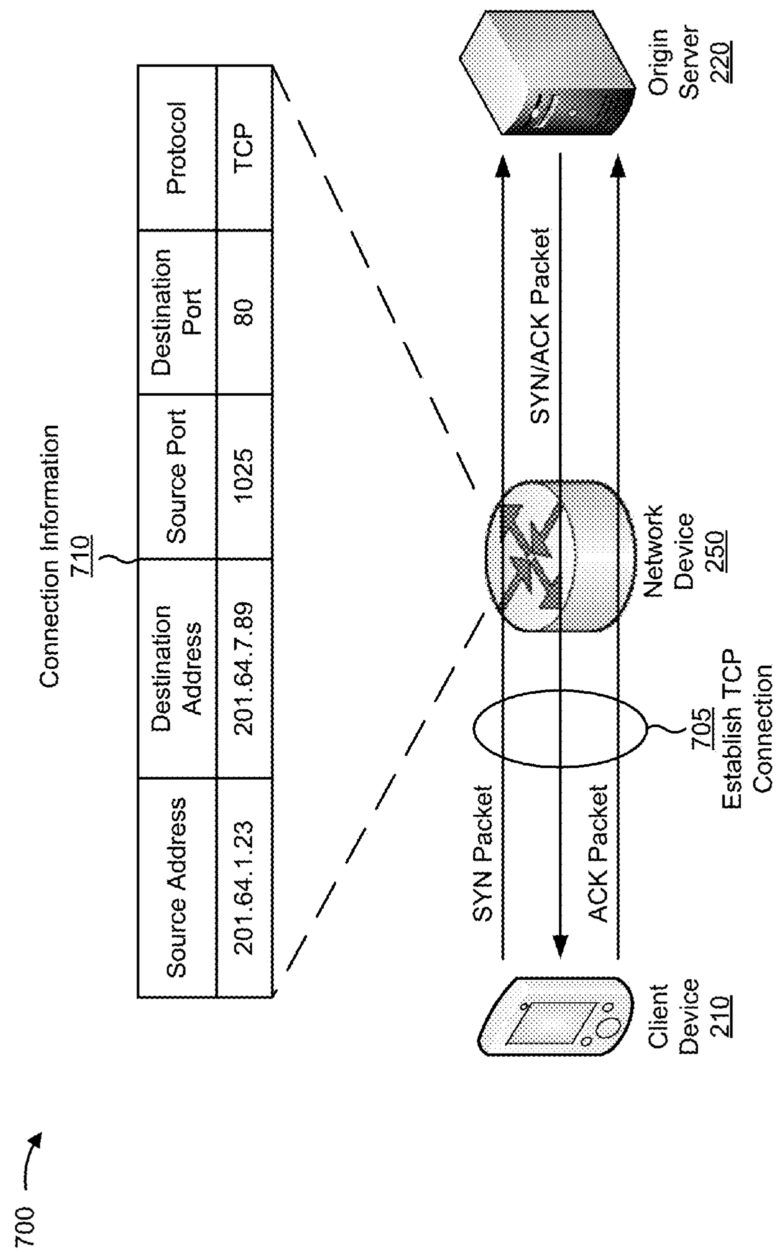

500
Client Device 210
Network Device 250
Proxy Server 240
Origin Server 220
505
Init., Terminate, Keep alive
SYN
SYN/ACK
ACK – TCP connection established
Client Request
Determine connection information
Select proxy server
CRTP Transfer Request
Validate CRTP transfer request
Confirm CRTP transfer request
CRTP Transfer Response
Terminate TCP connection
Establish TCP connectionland service client request
510
515
520
525
530
535
540
545
550
555
560
565

FIG. 5


Client Device 210
Network Device 250
Proxy Server 240
Origin Server 220
505
Initialize, Terminate, Keep alive
SYN
SYN/ACK
ACK – TCP connection established
Client Request
Determine connection information
Select proxy server
CRTP Transfer Request
Validate CRTP transfer request
Confirm CRTP transfer request
CRTP Transfer Response
Terminate TCP connection
Establish TCP connection and service client request
605
610
615
525
530
535
540
545
550
555
620
625

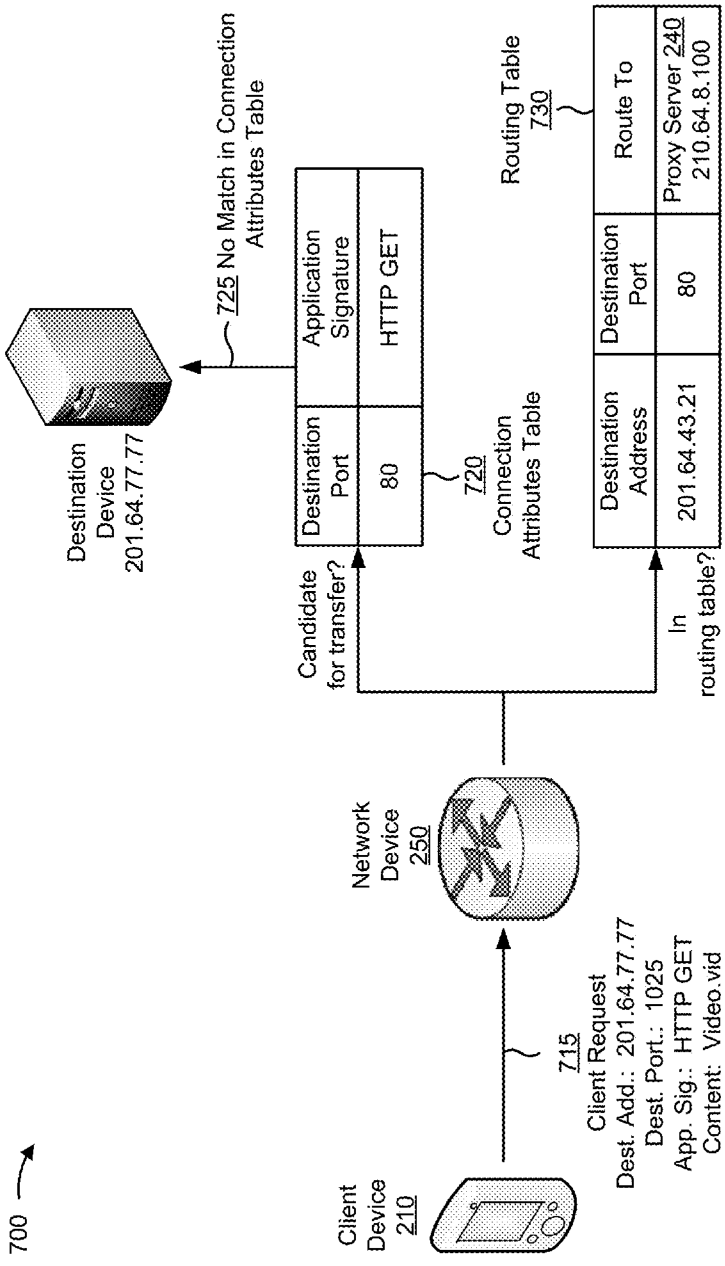
600

FIG. 6



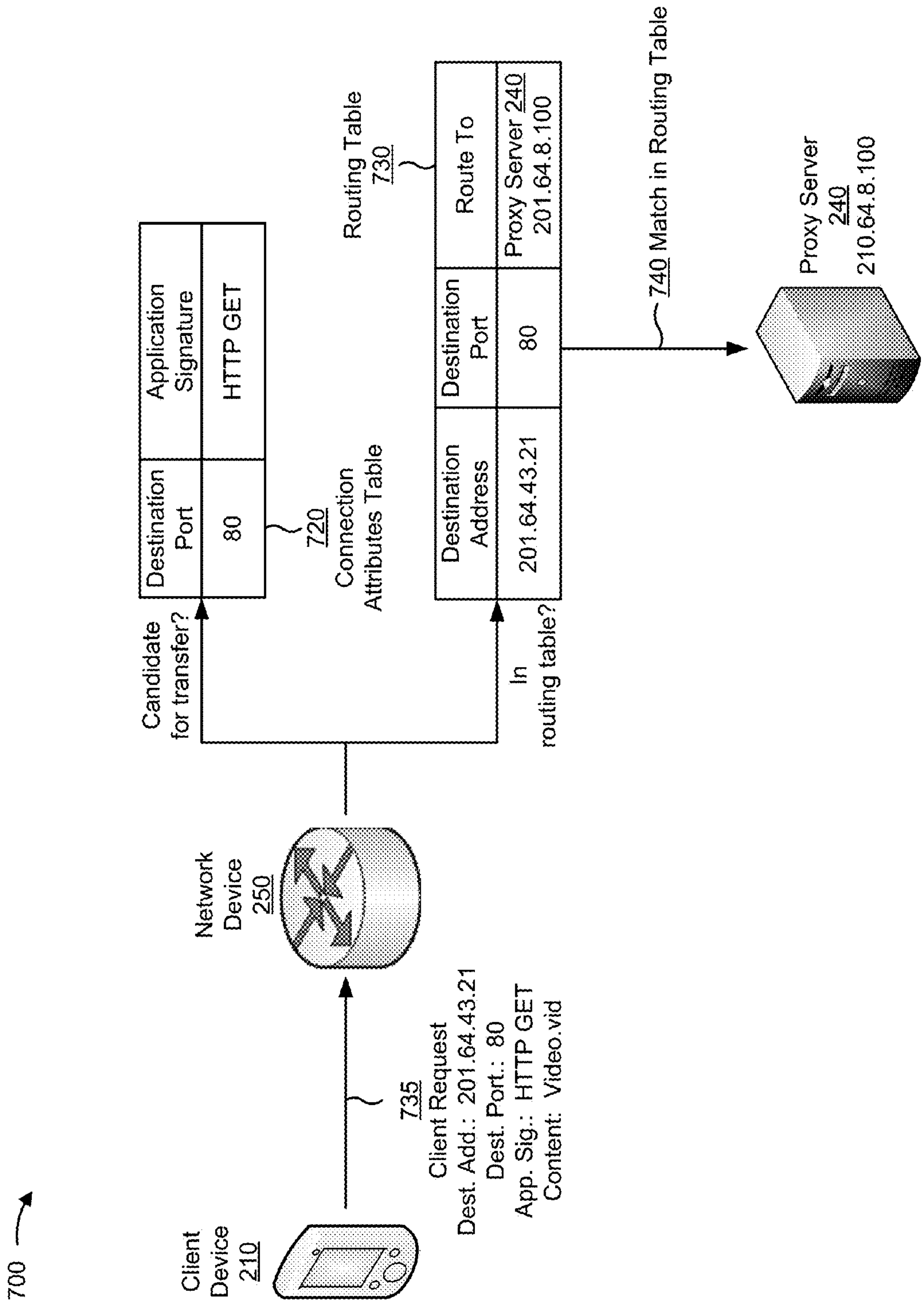
Source Address	Destination Address	Source Port	Destination Port	Protocol
201.64.1.23	201.64.7.89	1025	80	TCP

FIG. 7A



700
Client Device 210
715 Client Request
Dest. Add.: 201.64.77.77
Dest. Port.: 1025
App. Sig.: HTTP GET
Content: Video.vid
Network Device 250
Candidate for transfer?
In routing table?
Destination Port
Application Signature
80
HTTP GET
720 Connection Attributes Table
725 No Match in Connection Attributes Table
Destination Device 201.64.77.77
Routing Table 730
Destination Address
Destination Port
Route To
201.64.43.21
80
Proxy Server 240 210.64.8.100

FIG. 7B



700
Client Device 210
735 Client Request
Dest. Add.: 201.64.43.21
Dest. Port.: 80
App. Sig.: HTTP GET
Content: Video.vid
Network Device 250
Candidate for transfer?
In routing table?
Destination Port
Application Signature
80
HTTP GET
720 Connection Attributes Table
Routing Table 730
Destination Address
Destination Port
Route To
201.64.43.21
80
Proxy Server 240 201.64.8.100
740 Match in Routing Table
Proxy Server 240
210.64.8.100

FIG. 7C

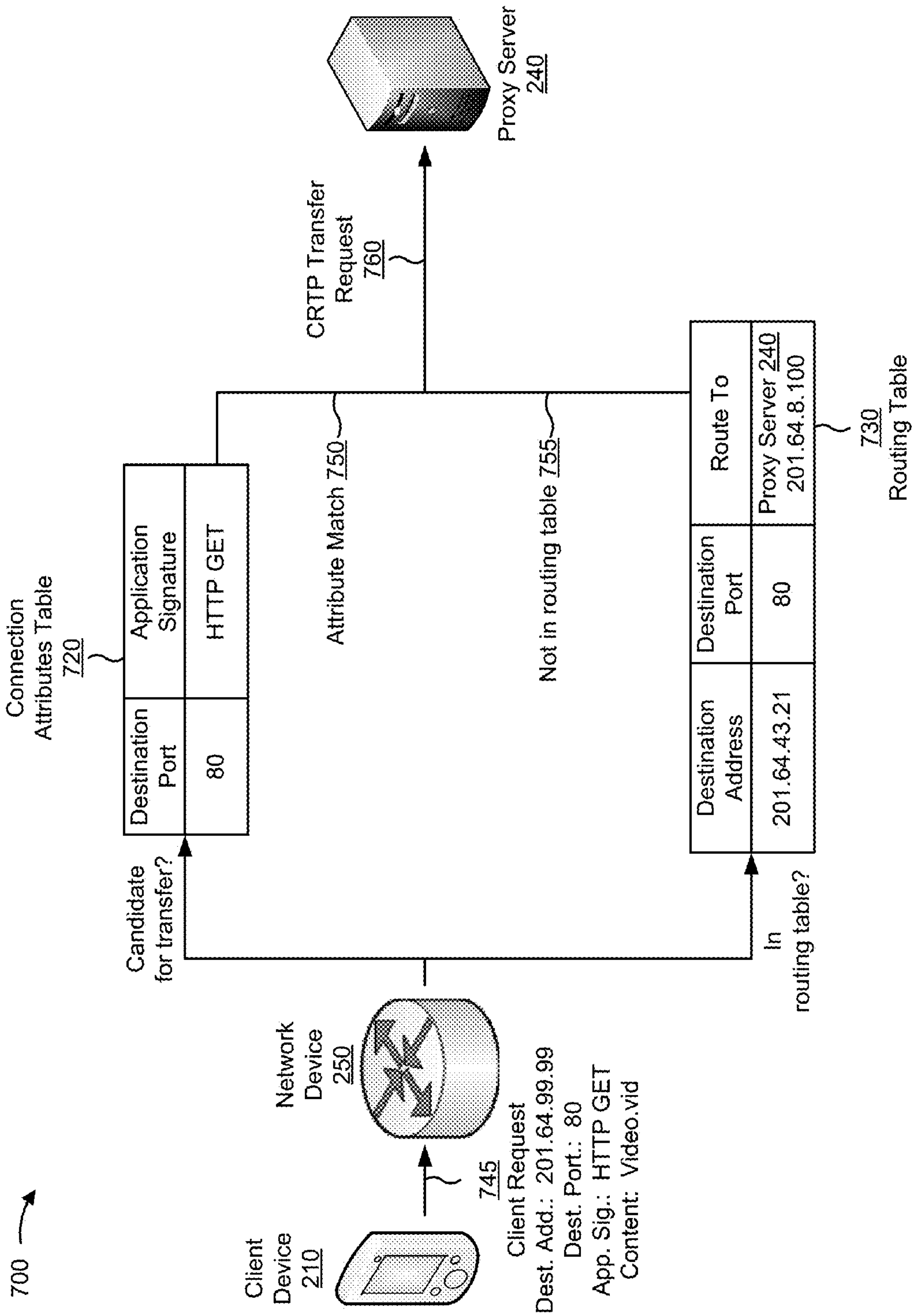

700
Client Device 210
745
Client Request
Dest. Add.: 201.64.99.99
Dest. Port.: 80
App. Sig.: HTTP GET
Content: Video.vid
Network Device 250
Candidate for transfer?
In routing table?
Connection Attributes Table 720
Destination Port
Application Signature
80
HTTP GET
Attribute Match 750
Not in routing table 755
Destination Address
Destination Port
Route To
201.64.43.21
80
Proxy Server 240 201.64.8.100
730 Routing Table
CRTP Transfer Request 760
Proxy Server 240

FIG. 7D

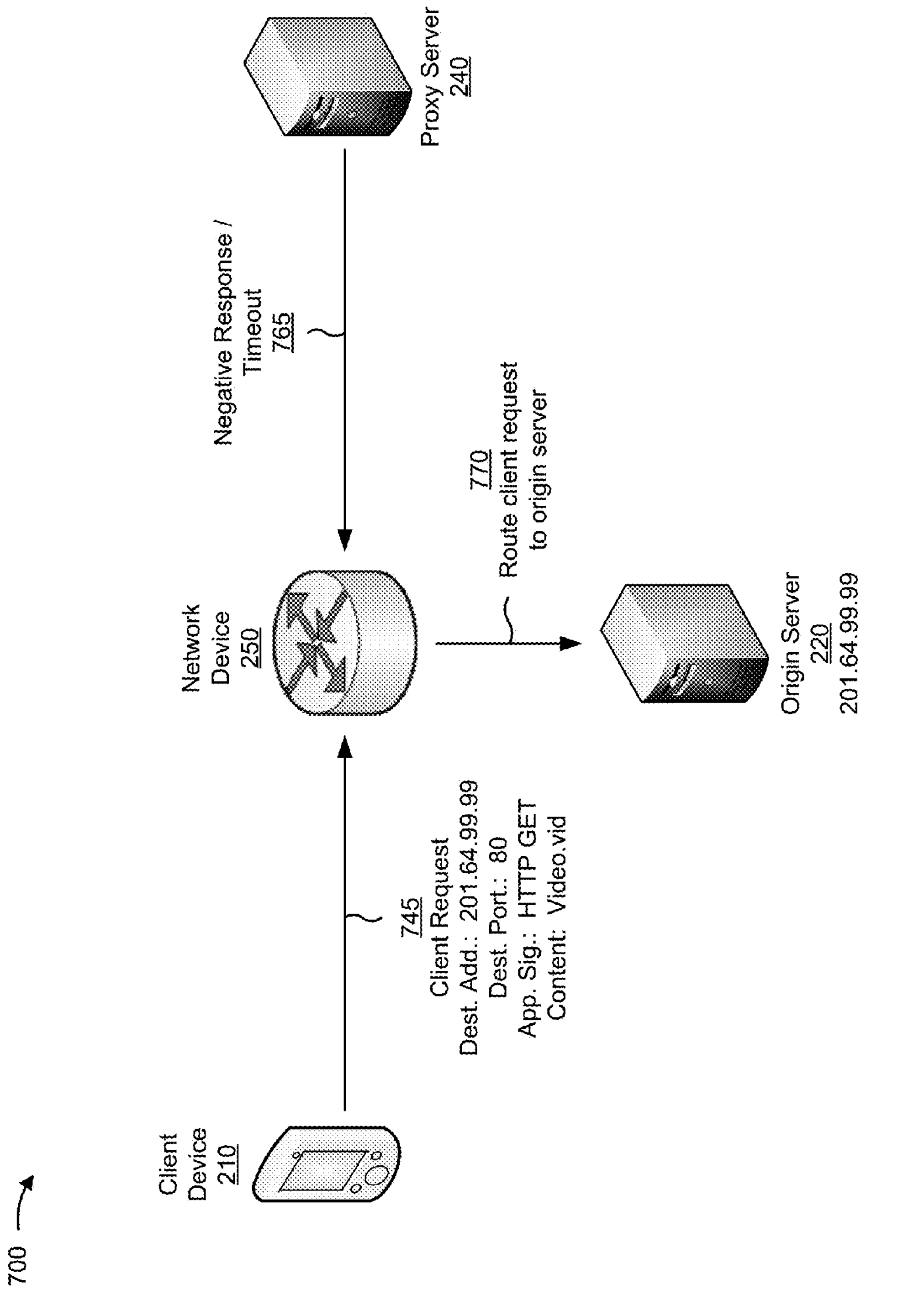

700
Proxy Server
240
Negative Response /
Timeout
765
Network
Device
250
770
Route client request
to origin server
Origin Server
220
201.64.99.99
Client
Device
210
745
Client Request
Dest. Add.: 201.64.99.99
Dest. Port.: 80
App. Sig.: HTTP GET
Content: Video.vid

FIG. 7E

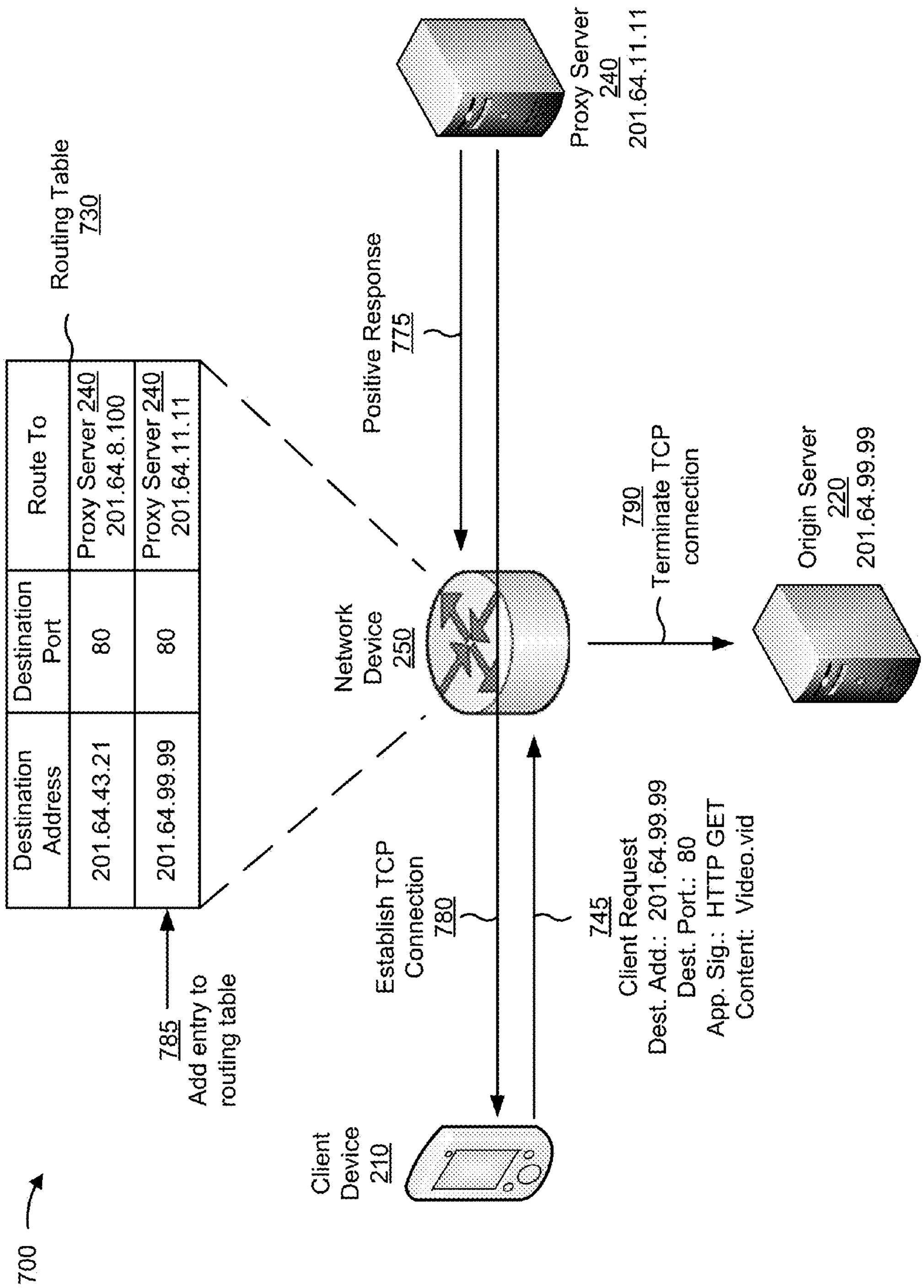

700
Routing Table 730
Destination Address
Destination Port
Route To
201.64.43.21
80
Proxy Server 240 201.64.8.100
201.64.99.99
80
Proxy Server 240 201.64.11.11
785 Add entry to routing table
Proxy Server 240 201.64.11.11
Positive Response 775
Network Device 250
790 Terminate TCP connection
Origin Server 220 201.64.99.99
Establish TCP Connection 780
745 Client Request
Dest. Add.: 201.64.99.99
Dest. Port.: 80
App. Sig.: HTTP GET
Content: Video.vid
Client Device 210

FIG. 7F

CONNECTION MANAGEMENT USING CONNECTION REQUEST TRANSFER PROTOCOL

BACKGROUND

A server cluster is a group of computers (sometimes referred to as servers, proxies, or nodes) interconnected via a local area network. The computers in the server cluster may work together to improve performance over the performance achieved by a single computer. For example, server clusters may improve information availability and response time through redundant data storage.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are diagrams of an overview of an example implementation described herein;

FIG. **2** is a diagram of an example environment in which systems and/or methods described herein may be implemented;

FIG. **3** is a diagram of example components of one or more devices of FIG. **2**;

FIG. **4** is a flow chart of an example process for transferring a connection to a proxy server;

FIGS. **5** and **6** are diagrams of example call flows for transferring a connection to a proxy server using a connection request transfer protocol (CRTP); and

FIGS. **7**A-**7**F are diagrams of example implementations relating to the example process shown in FIG. **4**.

DETAILED DESCRIPTION

The following detailed description of example implementations refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

A group of computers (sometimes referred to as servers, proxies, or nodes) interconnected via a local area network may be referred to as a server cluster (e.g., in a data center, a point of presence, etc.). The computers in the server cluster may work together to improve performance over the performance achieved by a single computer. For example, a server cluster may improve information availability and response time through redundant data storage. A set of servers that stores information also stored on one or more other servers may be referred to as a proxy cluster. The redundant storage may be referred to as a cache.

A proxy cluster may be used to service requests from client devices (e.g., personal computers, mobile devices, etc.). However, servicing client requests using a proxy cluster may cause processing delays due to bottlenecks at devices that analyze and route incoming requests and responses. Servicing the client requests with a proxy cluster may require complex routing policies for symmetric routing to ensure that requests and responses are routed through the same devices. The client requests may place a large demand on resources due to a need to intercept, track, and manage all connections (e.g., transmission control protocol (TCP) connections) that pass through the proxy cluster. Implementations described herein may alleviate such issues by using a connection request transfer protocol (CRTP) to intercept client device requests that can be serviced by the proxy cluster and to establish a direct connection (e.g., a TCP connection) between a proxy server in the cluster and the client device.

FIGS. **1**A and **1**B are diagrams of an overview of an example implementation **100** described herein. As shown in

FIG. **1**A, implementation **100** may include a client device, an origin server, a proxy server included in a proxy cluster, and a network device. The client device may include, for example, a personal computer or a mobile device. The origin server may include, for example, a server device. The proxy server may include, for example, one or more server devices included in the proxy cluster. The network device may include a router, a switch, etc. that may route traffic between the client device, the origin server, and/or the proxy server.

As further shown in FIG. **1**A, the network device may assist in establishing a connection (e.g., a transmission control protocol (TCP) connection) between the client device and the origin server. For example, the client device may request content, such as a video, from the origin server. The client device and the origin server may establish a TCP connection so that the origin server can respond to the request (e.g., by providing the content). The network device may receive the client request, may determine the origin server that provides the requested content, and may provide information to the client device and the origin server that assists in establishing the TCP connection between the client device and the origin server.

Once the TCP connection has been established, the network device may determine whether the client request can be serviced by the proxy server (e.g., in the proxy cluster). For example, the network device may determine whether the proxy server stores (e.g., caches) the requested content. If the requested content is not cached by the proxy server, the network device may forward the client request to the origin server.

As shown in FIG. **1**B, if the requested content is cached by the proxy server, the proxy server may terminate the TCP connection between the client device and the origin server (e.g., by sending a TCP termination command, to the origin sever, via the network device), and may respond to the client request by providing the requested content to the client device (e.g., via the network device). The response may establish a TCP connection between the client device and the proxy server, which may be used to service the client request. To establish the TCP connection, the proxy server may create an endpoint (e.g., may provision a socket, port, etc.) for TCP packets transmitted by the client device (e.g., packets that otherwise would have been transmitted to the origin server, but that have been intercepted by the network device and forwarded to the proxy server).

FIG. **2** is a diagram of an example environment **200** in which systems and/or methods described herein may be implemented. As shown in FIG. **2**, environment **200** may include a client device **210**, an origin server **220**, a proxy cluster **230**, a proxy server **240**, a network device **250**, and a network **260**. The devices of environment **200** may interconnect (e.g., via network **260**) via wired connections, wireless connections, or a combination of wired and wireless connections.

Client device **210** may include a device capable of accessing network **260** and/or communicating with the devices shown in FIG. **2**. For example client device **210** may include a desktop computer, a laptop computer, a tablet computer, a handheld computer, a smart phone, a radiotelephone, a gaming system, a set-top box, or a similar device. In some implementations, client device **210** may request content from origin server **220** and/or proxy server **240**, and may receive the requested content from origin server **220** and/or proxy server **240**.

Origin server **220** may include one or more servers (e.g., application servers, web servers, etc.), or similar types of computation and communication devices (e.g., a desktop computer, a laptop computer, etc.). Origin server **220** may store content, and may provide the content to client device **210** based on a request for the content.

Proxy cluster **230** may include one or more servers, or similar types of computation and communication devices, interconnected via a network (e.g., a local area network). For example, proxy cluster **230** may include multiple proxy servers **240**, which may be organized into a multi-tier structure (e.g., a multi-tier data center). Proxy cluster **230** may also include network device **250**. In some implementations, network device **250** may act as a tier one node in a multi-tier proxy cluster **230**, and proxy server **240** may act as a tier two node in a multi-tier proxy cluster **230**.

Proxy server **240** may include one or more servers, or similar types of computation and communication devices (e.g., a desktop computer, a laptop computer, etc.). Proxy server **240** may store content, and may provide the content to client device **210** based on a request for the content. In some implementations, proxy server **240** may store and/or provide content that is a duplicate of content stored by origin server **220**. In some implementations, proxy server **240** may include a device that manages one or more proxy servers **240** (e.g., a device that selects a proxy server **240** to provide content based on, for example, load balancing, server capabilities, an algorithm etc.). Additionally, or alternatively, proxy servers **240** may communicate with one another to coordinate content storage and availability, exchange service availability status, exchange connections to achieve load balancing, etc.

Network device **250** may include one or more traffic transfer devices. For example, network device **250** may include a router, a switch, a firewall, a hub, a bridge, a gateway, a modem, a network interface card (NIC), an optical add-drop multiplexer (OADM), a server, and/or another device capable of transmitting, receiving, transferring, and/or processing network traffic. Network device **250** may transfer traffic between and/or among the devices shown in FIG. **2**. In some implementations, network device **250** may be included in proxy cluster **230**. Additionally, or alternatively, network device **250** may be included in network **260**. In some implementations, a first network device **250** included in proxy cluster **230** may communicate with (e.g., by transferring traffic to and/or receiving traffic from) a second network device **250** included in network **260**.

Network **260** may include one or more wired and/or wireless networks. For example, network **260** may include a cellular network, a public land mobile network ("PLMN"), a radio access network, a local area network ("LAN"), a wide area network ("WAN"), a metropolitan area network ("MAN"), a telephone network (e.g., the Public Switched Telephone Network ("PSTN")), an ad hoc network, an intranet, the Internet, a fiber optic-based network, and/or a combination of these or other types of networks. In some implementations, network **260** may include a switch, or another traffic transfer device, that connects network device **250** to proxy server **240**.

The number of devices/networks shown in FIG. **2** is provided for explanatory purposes. In practice, environment **200** may include additional devices/networks, fewer devices/networks, different devices/networks, or differently arranged devices/networks. Furthermore, two or more devices shown in FIG. **2** may be implemented within a single device, or a single device shown in FIG. **2** may be implemented as multiple, distributed devices. Additionally, one or more of the devices of environment **200** may perform one or more functions described as being performed by another one or more devices of environment **200**.

FIG. **3** is a diagram of example components of a device **300**. Device **300** may correspond to client device **210**, origin server **220**, proxy server **240**, and/or network device **250**. As shown in FIG. **3**, device **300** may include a bus **310**, a processor **320**, a memory **330**, an input component **340**, an output component **350**, and a communication interface **360**.

Bus **310** may include a path that permits communication among the components of device **300**. Processor **320** may include a processor (e.g., a central processing unit, a graphics processing unit, an accelerated processing unit), a microprocessor, and/or any processing logic (e.g., a field-programmable gate array ("FPGA"), an application-specific integrated circuit ("ASIC"), etc.) that interprets and/or executes instructions. Memory **330** may include a random access memory ("RAM"), a read only memory ("ROM"), and/or another type of dynamic or static storage device (e.g., a flash, magnetic, or optical memory) that stores information and/or instructions for use by processor **320**.

Input component **340** may include a component that permits a user to input information to device **300** (e.g., a touch screen display, a keyboard, a keypad, a mouse, a button, a switch, etc.). Output component **350** may include a component that outputs information from device **300** (e.g., a display, a speaker, one or more light-emitting diodes ("LEDs"), etc.).

Communication interface **360** may include a transceiver-like component, such as a transceiver and/or a separate receiver and transmitter, that enables device **300** to communicate with other devices, such as via a wired connection, a wireless connection, or a combination of wired and wireless connections. For example, communication interface **360** may include an Ethernet interface, an optical interface, a coaxial interface, an infrared interface, a radio frequency ("RF") interface, a universal serial bus ("USB") interface, or the like.

Device **300** may perform various operations described herein. Device **300** may perform these operations in response to processor **320** executing software instructions included in a computer-readable medium, such as memory **330**. A computer-readable medium may be defined as a non-transitory memory device. A memory device may include memory space within a single storage device or memory space spread across multiple storage devices.

Software instructions may be read into memory **330** from another computer-readable medium or from another device via communication interface **360**. When executed, software instructions stored in memory **330** may cause processor **320** to perform one or more processes described herein. Additionally, or alternatively, hardwired circuitry may be used in place of or in combination with software instructions to perform one or more processes described herein. Thus, implementations described herein are not limited to any specific combination of hardware circuitry and software.

The number of components shown in FIG. **3** is provided for explanatory purposes. In practice, device **300** may include additional components, fewer components, different components, or differently arranged components than those shown in FIG. **3**. Additionally, or alternatively, each of client device **210**, origin server **220**, proxy server **240**, and/or network device **250** may include one or more devices **300** and/or one or more components of device **300**.

FIG. **4** is a flow chart of an example process **400** for transferring a connection to a proxy server. In some implementations, one or more process blocks of FIG. **4** may be performed by network device **250**. Additionally, or alternatively, one or more process blocks of FIG. **4** may be performed by another device or a group of devices separate from or including network device **250**, such as proxy server **240**.

As shown in FIG. **4**, process **400** may include receiving, from a client device, a client request that identifies an origin server to provide requested content (block **410**). For example, network device **250** may receive the client request, and may analyze the client request to determine an origin server **220** to provide content requested in the client request. In some implementations, the client request may include a packet that identifies origin server **220** as a destination. The requested content may include textual content, an image, media content (e.g., audio, video, etc.), streaming content, a web page, or any other content.

As further shown in FIG. **4**, process **400** may include establishing a transmission control protocol (TCP) connection between the client device and the origin server (block **420**). For example, network device **250** may provide, to client device **210** and/or origin server **220**, connection information that assists in establishing a TCP connection. Client device **210** and origin server **220** may use the connection information to establish a TCP connection.

The connection information may include information that identifies, for example, a source network address associated with the TCP connection (e.g., an Internet protocol (IP) address of client device **210**); a destination network address associated with the TCP connection (e.g., an IP address of origin server **220**); a source port associated with the TCP connection (e.g., that serves as an endpoint for the TCP connection on client device **210**); a destination port associated with the TCP connection (e.g., that serves as an endpoint for the TCP connection on origin server **220**); a sequence number associated with the TCP connection (e.g., an initial receive sequence number from client device **210** and/or origin server **220**, an initial send sequence number from client device **210** and/or origin server **220**, a current sequence number from client device **210** and/or origin server **220**, etc.); an acknowledgement number associated with the TCP connection; a window size associated with the TCP connection, a protocol associated with the TCP connection (e.g., IP version 4 (IPv4), IP version 6 (IPv6), etc.); an application signature associated with the TCP connection (e.g., a GET, HEAD, extended hello (EHLO), HELO, etc. signature or command identified in the client request); etc. In some implementations, the connection information may be identified in the client request (e.g., in a packet included in the client request).

In some implementations, the TCP connection may be established by a three-way handshake process. For example, client device **210** may transmit, to origin server **220** (via network device **250**), a packet that includes a request for a TCP connection to be established, also known as a SYN (synchronize) packet. Origin server **220** may receive the SYN packet, and may transmit, to client device **210** (via network device **250**), a packet that includes an acknowledgement that the SYN packet was received, also known as a SYN/ACK (synchronize/acknowledgement) packet. Client device **210** may receive the SYN/ACK packet, and may transmit, to origin server **220** (via network device **250**), a packet that includes an acknowledgement that the SYN/ACK packet was received, also known as an ACK (acknowledgement) packet. A TCP connection between client device **210** and origin device **220** may be established using this three-way handshake process (SYN, SYN/ACK, and ACK).

As shown in FIG. **4**, process **400** may include determining whether the client request is a candidate for a connection transfer (block **430**). For example, network device **250** may determine whether the client request is a candidate for connection transfer based on the connection information associated with the client request, such as a TCP port (e.g., a source port, a destination port, etc.), an application signature (e.g., GET, HEAD, EHLO, etc.), a protocol associated with the client request, and/or other connection information (e.g., a uniform resource locator (URL) associated with an HTTP request, a header associated with an HTTP request, etc.) identified in the client request. Additionally, or alternatively, network device **250** may determine whether the client request is a candidate for connection transfer based on whether the connection information associated with the client request (e.g., a destination address, a destination port, etc.) is identified in a data structure (e.g., a routing table) accessible by network device **250**.

If the client request is not a candidate for the connection transfer (block **430**—NO), then process **400** may include routing the client request to a destination device associated with the client request (block **440**). For example, if network device **250** determines that the connection information identified by the client request does not meet one or more criteria (e.g., stored in a data structure accessible by network device **250**), then network device **250** may route the client request to a destination device identified in the request (e.g., origin server **220**). For example, if the client request is not associated with a TCP protocol, a particular TCP port, a particular network address, a particular application signature, etc., then network device **250** may route the client request to origin server **220**. Additionally, or alternatively, if network device **250** determines that the client request is identified in a routing table (e.g., identified by destination network address, destination port, etc.), then network device **250** may route the client request to a destination device identified in the routing table as being associated with the client request (e.g., origin server **220**, proxy server **240**, or another device).

If the client request is a candidate for the connection transfer (block **430**—YES), then process **400** may include determining whether the client request can be serviced by a proxy server (block **450**). For example, if network device **250** determines, based on the connection information associated with the client request (e.g., as explained in connection with blocks **430** and **440**, above), that the client request is a candidate for a connection transfer, then network device **250** may determine whether the client request can be serviced by proxy server **240**.

In some implementations, network device **250** may determine whether the client request can be serviced by proxy server **240** by analyzing the client request to determine whether the client request is associated with cacheable or non-cacheable information. Additionally, or alternatively, network device **250** may transmit, to proxy server **240**, information that identifies the content requested by client device **210**. Proxy server **240** may determine whether the requested content is stored by proxy server **240** (or another proxy server **240** in proxy cluster **230**), and may transmit, to network device **250**, an indication of whether the requested content is stored by and/or accessible by proxy server **240**. Network device **250** may determine whether the client request can be serviced by proxy server **240** based on the received indication.

If the client request cannot be serviced by the proxy server (block **450**—NO), then process **400** may include routing the client request to a destination device associated with the client request (block **440**). For example, if network device **250** determines that the client request is for non-cacheable information (e.g., bank account information, credit card information, sensitive personal information, etc.), then network device **250** may route the client request to origin server **220**. Additionally, or alternatively, if network device **250** receives an indication that proxy server **240** does not store the requested content, then network device **250** may route the client request to origin server **220**.

If the client request can be serviced by the proxy server (block **450**—YES), then process **400** may include selecting a proxy server to service the client request (block **460**). For example, if network device **250** determines that the client request is for cacheable information (e.g., streaming audio or video, a broadcast, a cacheable web page, etc.), and/or if network device **250** receives an indication that proxy server **240** can provide the requested content, then network device **250** may select a proxy server **240** to service the client request.

In some implementations, network device **250** may select a proxy server **240** to service the client request based on one or more algorithms, such as a round robin algorithm, a load balancing algorithm (e.g., least load first), an application hash algorithm, a least connections algorithm (e.g., least connections first), and/or a weighted version of these or other algorithms. In some implementations, network device **250** may select a proxy server **240** to service the request when determining whether a proxy server **240** can service the request. For example, when transmitting, to proxy server **240**, the information that identifies the content requested by client device **210**, network device **250** may include a hash algorithm that may be applied to select a proxy server **240** to service the client request.

As shown in FIG. **4**, if the client request can be serviced by a proxy server (block **450**—YES), then process **400** may further include transmitting, to the selected proxy server, connection information associated with the TCP connection (block **470**). For example, network device **250** may transmit connection information, associated with the TCP connection between client device **210** and origin server **220**, to proxy server **240**. In some implementations, network device **250** may transmit the connection information to proxy server **240** along with the information that identifies the content requested by client device **210**. The connection information may identify, for example, a network address, a port number, a sequence number, an acknowledgement number, a window size, a protocol, an application signature, etc., as described elsewhere herein.

As shown in FIG. **4**, if the client request can be serviced by a proxy server (block **450**—YES), then process **400** may further include establishing, based on the connection information, a TCP connection between the client device and the selected proxy server (block **480**), and terminating, based on the connection information, the TCP connection between the client device and the origin server (block **490**). For example, proxy server **240** may use the connection information, received from network device **250**, to create a TCP connection endpoint (e.g., a port, a socket, etc.) on proxy server **240** for a TCP connection with client device **210**. Additionally, or alternatively, proxy server **240** may use the connection information, received from network device **250**, to terminate the TCP connection (e.g., to terminate a TCP connection endpoint on origin server **220**) between client device **210** and origin server **220**. In some implementations, proxy server **240** may establish the TCP connection (e.g., by creating an endpoint) without transmitting a TCP control packet to client device **210**.

In some implementations, rather than terminating a TCP connection between client device **210** and origin server **220**, and establishing a TCP connection between client device **210** and proxy server **240**, process **400** may include terminating a TCP connection between client device **210** and a first proxy server **240**, and establishing a TCP connection between client device **210** and a second proxy server **240**. In other words, process **400** may include transferring a TCP connection from an origin server **220** to a proxy server **240**, and/or transferring a TCP connection from a first proxy server **220** to a second, different proxy server **240**.

While a series of blocks has been described with regard to FIG. **4**, the blocks and/or the order of the blocks may be modified in some implementations. For example, in some implementations, process block **450** may occur before process block **430**. In some implementations, process block **460** may occur before and/or concurrently with process block **430**. Additionally, or alternatively, non-dependent blocks may be performed in parallel.

FIG. **5** is a diagram of an example call flow **500** for transferring a connection to a proxy server using a connection request transfer protocol (CRTP). Call flow **500** may use CRTP in an asymmetric proxy cluster **230** to service client requests via proxy server **240**. An asymmetric proxy cluster **230** may route traffic from client device **210** to origin server **220** via a different route than traffic from origin server **220** to client device **210**.

Network device **250** may assist with transferring TCP connections, with client device **210**, from origin server **220** to proxy server **240**. For example, origin server **220** may service a client request from client device **210** via a TCP connection. Network device **250** may assist in terminating the TCP connection between origin server **220** and client device **210**, and establishing a TCP connection between proxy server **240** and client device **210** so that proxy server **240** may service the client request from client device **210**.

In some implementations, network device **250** may determine whether the content requested by client device **210** is available on proxy server **240**. This content check may be performed at the application layer of the TCP/IP protocol (e.g., layer 7 of the open systems interconnection (OSI) model), and the TCP connection transfer may be performed at the transport layer of the TCP/IP protocol (e.g., layer 4 of the OSI model). Connection request transfer protocol (CRTP) may assist in communication and coordination between the application layer (layer 7) and the transport layer (layer 4).

CRTP may be implemented as an application layer protocol, and may use TCP as a means for transportation at the transport layer. CRTP may be used to transfer a TCP connection from one node (e.g., origin server **220**) to another node (e.g., proxy server **240**). Additionally, or alternatively, CRTP may transfer application information from one node to another node. In some implementations, CRTP information and/or connection information (e.g., TCP connection information) described herein may be included in a client request (e.g., as an extension to HTTP). Additionally, or alternatively, CRTP may use user datagram protocol (UDP) as a means for transportation at the transport layer.

As shown by reference number **505**, network device **250** and proxy server **240** may use CRTP to initialize, terminate, and/or keep alive a communication channel.

To initialize a communication channel between network device **250** and proxy server **240**, network device **250** may transmit, to proxy server **240**, a CRTP initialization request, and may receive a CRTP initialization response. Initialization may include using a mechanism (e.g., a cookie) that stores security information to protect against security attacks. For example, proxy server **240** may store security information (e.g., a hash value, a pre-shared key value, etc., which may be periodically changed). When sending the CRTP initialization request, network device **250** may request the security information. Proxy server **240** may transmit, in the CRTP initialization response, information that identifies the stored security information. Network device **250** may verify the received security information before completing initialization of the communication channel.

To terminate a communication channel between network device **250** and proxy server **240**, network device **250** may transmit, to proxy server **240**, a CRTP termination request, and may receive a CRTP termination response. The termination may remove proxy server **240** from association with proxy cluster **230**.

Network device **250** may periodically send a CRTP keep-alive request to proxy server **240**. If network device **250** does not receive a CRTP keep-alive response within a particular time period, network device **250** may terminate the communication channel. The CRTP keep-alive request may include a request for security information. Proxy server **240** may transmit, in the CRTP keep-alive response, security information stored by proxy server **240**. Network device **250** may verify the received security information to keep the communication channel active. If the received security information is invalid, network device **250** may terminate the communication channel.

As shown by reference numbers **510-520**, call flow **500** may include establishing a TCP connection between client device **210** and origin server **220** via a three-way handshake process. For example, as shown by reference number **510**, client device **210** may transmit, to origin server **220** (via network device **250**), a SYN packet. In some implementations, network device **250** may mute and/or remove information that identifies TCP options, included in a TCP header of the SYN packet, before routing the SYN packet to origin server **220**. As shown by reference number **515**, origin server **220** may transmit, to client device **210** (via network device **250**), a SYN/ACK packet. As shown by reference number **520**, client device **210** may transmit, to origin server **220** (via network device **250**), an ACK packet. A TCP connection between client device **210** and origin device **220** may be established using this three-way handshake process (SYN, SYN/ACK, and ACK).

As shown by reference number **525**, client device **210** may transmit, to network device **250**, a client request. For example, the client request may include an application signature, such as a hypertext transfer protocol (HTTP) request (e.g., a GET request, a HEAD request, an HTTP/1.1 request, etc.), a simple mail transfer protocol (SMTP) request (e.g., a HELO request, an EHLO request, etc.), etc. In some implementations, network device **250** may intercept the client request without client device **210** explicitly transmitting the client request to network device **250**.

As shown by reference number **530**, network device **250** may determine connection information associated with the TCP connection and/or identified in the client request. For example, network device **250** may determine a source network address, a destination network address, a source port, a destination port, a sequence number, an acknowledgement number, a window size, etc., associated with the TCP connection. Additionally, or alternatively, network device **250** may determine application information associated with the TCP connection, such as an application associated with the TCP connection, application requirements associated with the TCP connection (e.g., bandwidth requirements, capacity requirements, jitter requirements, packet delay requirements, quality of service requirements, etc.), etc.

In some implementations, network device **250** may create a connection identifier for the TCP connection. Network device **250** may associate the connection identifier with packets associated with the TCP connection. The connection identifier may be used by network device **250** and/or proxy server **240** to identify packets associated with the TCP connection to be transferred from origin server **220** to proxy server **240**. In some implementations, network device **250** more store the connection identifier, the connection information, and/or the application information in a data structure in order to track packets associated with the TCP connection.

As shown by reference number **535**, network device **250** may select a proxy server **240** to service the client request. In some implementations, network device **250** may determine a selection algorithm used to select the proxy server **240**. For example, the selection algorithm may be based on a round robin algorithm; a load balancing algorithm (e.g., least load first, most load first, etc.); an application hash algorithm (e.g., determining proxy server **240** based on an application associated with the TCP connection); a least connections algorithm (e.g., determining a proxy server **240** with the least number of established TCP connections); an enforced transfer algorithm (e.g., forcing a particular proxy server **240** to handle a particular TCP connection); and/or a weighted version of these or other algorithms.

In some implementations, the CRTP keep-alive request, transmitted by network device **250** to proxy server **240**, may include information that identifies the selection algorithm. Additionally, or alternatively, the CRTP keep-alive response, transmitted by proxy server **240** to network device **250**, may include status information that assists network device **250** in selecting a proxy device **240** using the selection algorithm. For example, the CRTP keep-alive request may identify a selection algorithm of least connections first, where network device **250** selects a proxy server **240**, with the least number of established TCP connections, to service the client request. In this example, the CRTP keep-alive response may identify a number of TCP connections that have been established with proxy server **240**. In this way, network device **250** may compare the number of TCP connections associated with multiple proxy servers **240**, based on the status information identified in the CRTP keep-alive response received from each of the multiple proxy servers **240**.

In some implementations, network device **250** may receive input (e.g., from a user and/or another device) to change the selection algorithm. For example, network device **250** may receive input to change the selection algorithm to a least load first algorithm, where network device **250** selects a proxy server **240** with the least load to service the client request. Subsequent CRTP keep-alive messages, transmitted by network device **250**, may identify the least load first algorithm. In this example, the CRTP keep-alive response may identify a load on proxy server **240** that transmits the CRTP keep-alive response (e.g., a processing load, a memory load, etc.). In this way, network device **250** may select a proxy server **240** with a least amount of load to service the client request.

In some implementations, network device **250** may not use a selection algorithm. For example, network device **250** may use UDP as a transportation means for CRTP messages, and may operate in a multicast mode. In multicast mode, network device **250** may transmit the CRTP request to a multicast address that identifies multiple proxy servers **240** in proxy cluster **230**. A proxy server **240** that is capable of servicing the client request may transmit a positive acknowledgement (ACK) that the client request can be serviced.

As shown by reference number **540**, network device **250** may transmit a CRTP transfer request to the selected proxy server **240**. The CRTP transfer request may include a connection transfer request that a TCP connection be transferred from a first device (e.g., origin server **220**) to a second device (e.g., proxy server **240**). In some implementations, the CRTP transfer request may identify the connection information (e.g., a source IP address, a destination IP address, an initial receive sequence (IRS) number, an initial send sequence (ISS) number, a source port, a destination port, etc. associated with the TCP connection), the application information, the client request, and/or the connection identifier.

In some implementations, the CRTP transfer request may include a packet that identifies a packet acknowledgement number and/or a packet sequence number. Network device **250** and/or proxy server **240** may determine an ISS number based on the packet acknowledgement number, such as by subtracting one from the packet acknowledgement number (PAN) (e.g., ISS=PAN−1). Likewise, network device **250** and/or proxy server **240** may determine an IRS number based on the packet sequence number, such as by subtracting one from the packet sequence number (PSN) (e.g., IRS=PSN−1). Network device **250** and/or proxy server **240** may use the ISS and IRS numbers to establish the TCP connection between client device **210** and proxy server **240** (e.g., to include the correct sequence and/or acknowledgement number in a packet included in a response to the client request).

Additionally, or alternatively, when transmitting the CRTP transfer request, network device **250** may queue a packet (or information that identifies a packet) associated with the client request. For example, network device **250** may queue packets based on priority. Network device **250** may compose a CRTP transfer request for a packet at the head of the queue, and may transmit the CRTP request to proxy server **240**. Network device **250** may determine an amount of time that has passed since a packet was placed in the queue. If the amount of time satisfies (e.g., is equal to or greater than) a threshold, then network device **250** may route the packet to origin server **220**. In some implementations, the threshold may be based on a TCP retransmission timeout value. In some implementations, the threshold may be based on and/or calculated according to:

$$TO_{CRTP}=\mathrm{SRTT}\pm\max\{G,K\times \mathrm{RTT}_{VAR}\},$$

where TO_{CRTP} may be the threshold in seconds (e.g., a CRTP timeout value), SRTT may be a smoothed round-trip time in seconds (e.g., an estimated length of time for a TCP packet to be sent and a TCP acknowledgement to be received), RTT_{VAR} may be a variation, in seconds, of the round-trip time, G may be a clock granularity in seconds, and K may be a user-input and/or machine-input constant (e.g., four).

As shown by reference number **545**, proxy server **240** may validate the CRTP transfer request. For example, a packet included in the CRTP transfer request may include security information, such as a security key, a coded value, a hash value, etc. Proxy server **240** may validate the packet using, for example, a decoder, a hash function, etc.

As shown by reference number **550**, proxy server **240** may confirm the CRTP transfer request. For example, proxy server **240** may determine whether the client request may be serviced by proxy server **240**. In some implementations, proxy server **240** may determine whether content, requested in the client request, is stored by and/or accessible by proxy server **240**. Additionally, or alternatively, proxy server **240** may determine whether proxy server **240** is able to service the request based on the connection information and/or the application information (e.g., application requirements).

As shown by reference number **555**, proxy server **240** may transmit, to network device **250**, a CRTP transfer response. The CRTP transfer response may include, for example, a positive response (e.g., an ACK) or a negative response (e.g., a NACK). If the CRTP transfer response includes a negative response (e.g., if proxy server **240** cannot service the client request), then network device **250** may route the client request to origin server **220**. If the CRTP transfer response includes a positive response (e.g., if proxy server **240** can service the client request), then network device **250** and/or proxy server **240** may terminate the TCP connection between client device **210** and origin server **220** (e.g., as indicated by reference number **560**), and may establish a TCP connection between client device **210** and proxy server **240** to service the client request (e.g., as indicated by reference number **565**).

In some implementations, the CRTP transfer response may include connection information associated with proxy server **240**. For example, the CRTP transfer response may include a policy-based routing value that indicates which packets are to be routed to proxy server **240** (e.g., based on connection information identified in the packets). Network device **250** may route the packet (and/or other packets) identified by the CRTP transfer request/response to proxy sever **240**.

As shown by reference number **560**, network device **250** and/or proxy server **240** may terminate the TCP connection between client device **210** and origin server **220**. In some implementations, proxy server **240** may terminate the TCP connection by sending a TCP reset command to origin server **220**. The TCP reset command may use the connection information to spoof client device **210**. For example, the TCP reset command may identify a source network address, a source port, etc. associated with client device **210**. Origin server **220** may terminate the TCP connection with client device **210** based on receiving the TCP reset command.

As shown by reference number **565**, network device **250** may assist in establishing a TCP connection between proxy server **240** and client device **210**, and proxy server **240** may service the client request. In some implementations, network device **250** may determine connection information associated with the TCP connection, and may transmit the connection information, to proxy server **240**, along with a command that causes proxy server **240** to establish the TCP connection (e.g., by establishing a TCP socket to receive and/or transmit information associated with the client request). In some implementations, proxy server **240** may service the client request by providing the content, requested by client device **210** in the client request, to client device **210**. In some implementations, proxy server **240** may provide the content to client device **210** via network device **250**. Alternatively, proxy server **240** may provide the content to client device **210** without using network device **250**. For example, proxy server **240** may provide the requested content to client device **210** by direct server return.

While a series of communications has been described with regard to FIG. **5**, the communications and/or the order of the communications may be modified in some implementations. Additionally, or alternatively, non-dependent communications may be performed in parallel.

FIG. **6** is a diagram of an example call flow **600** for transferring a connection to a proxy server using the CRTP. FIG. **6** shows call flow **600** using a symmetric proxy cluster **230**. A symmetric proxy cluster **240** may route traffic from client device **210** to origin server **220** via the same route as traffic from origin server **220** to client device **210**. In some implementations, the call flow of FIG. **6** may apply when network device **250** is a load balancing device (e.g., a layer 7 load balancer) that filters and distributes incoming traffic to proxy cluster **230** (and/or outgoing traffic to client device **210**). In this scenario, proxy servers **240** in proxy cluster **230** may share a virtual IP address.

As shown by reference numbers **605-615**, network device **250** may intercept a request from client device **210** to establish a TCP connection with origin server **220**. Intercepting the request may include establishing a TCP connection between client device **210** and network device **250** via a three-way handshake process. For example, as shown by reference number **605**, client device **210** may transmit, and network device **250** may intercept and receive, a SYN packet. As shown by reference number **610**, network device **250** may transmit, to client device **210**, a SYN/ACK packet (e.g., which may spoof the destination address, destination port, etc. associated with origin server **220**). As shown by reference number **615**, client device **210** may transmit, and network device **250** may intercept and receive, an ACK packet. A TCP connection between client device **210** and network device **250** may be established using this three-way handshake process (SYN, SYN/ACK, and ACK).

Reference numbers **505** and **525-555** may be performed as described in connection with FIG. **5**. For example, network device **250** may receive a client request, may transmit a CRTP request to proxy server **240** to determine whether proxy server **240** can service the client request, and may receive a CRTP response from proxy server **240**.

If the CRTP response includes a positive response (e.g., if proxy server **240** can service the CRTP request), then network device **250** may terminate the TCP connection between client device **210** and network device **250** (reference number **620**), and proxy server **240** may establish a TCP connection with client device **210** to service the client request (reference number **625**).

While a series of communications has been described with regard to FIG. **6**, the communications and/or the order of the communications may be modified in some implementations. Additionally, or alternatively, non-dependent communications may be performed in parallel.

FIGS. **7A-7F** are diagrams of example implementations **700** relating to the example process shown in FIG. **4**.

As shown in FIG. **7A**, network device **250** may assist in establishing a TCP connection between client device **210** and origin server **220**. For example, network device **250** may route a SYN packet from client device **210** to origin server **220**, may route a SYN/ACK packet from origin server **220** to client device **210**, and may route an ACK packet from client device **210** to origin server **220**. As shown by reference number **705**, this three-way handshake may establish a TCP connection between client device **210** and origin server **220**.

As shown by reference number **710**, network device **250** may determine connection information associated with the TCP connection (e.g., connection information identified in one or more of the SYN packet, the SYN/ACK packet, and/or the ACK packet). The connection information may include, for example, a source address (e.g., an IP address of client device **210**), a destination address (e.g., an IP address of origin server **220**), a source port (e.g., an endpoint or socket associated with the TCP connection on client device **210**), a destination port (e.g., an endpoint or socket associated with the TCP connection on origin server **220**), a protocol associated with the TCP connection (e.g., TCP), etc. In some implementations, network device **250** may store the connection information in a data structure, as shown by reference number **710**, and may use the stored information to track packets associated with the TCP connection and/or a client request.

As shown in FIG. **7B**, network device **250** may receive, from client device **210**, a client request **715**. The client request (which may include, e.g., a packet) may identify a destination address (201.64.77.77), a destination port (port 1025), an application signature (HTTP GET), requested content (video.vid), other connection information, and/or other information associated with requested content (e.g., application information).

Network device **250** may determine whether client request **715** is a candidate for a TCP connection transfer by comparing connection information identified by client request **715** to connection information stored in connection attributes table **720** (e.g., a data structure). Connection attributes table **720** may identify one or more attributes that qualify a client request for a connection transfer. For example, connection attributes table **720** may indicate that packets identifying a destination port of 80 and/or an application signature of HTTP GET are candidates for a connection transfer.

As shown by reference number **725**, the attributes of client request **715** (e.g., destination port 1025) do not match the attributes stored in connection attributes table **720** (e.g., destination port 80). As a result, network device **250** may route client request **715** to a destination device identified in client request **715** (e.g., a destination device identified by IP address 201.64.77.77). Additionally, or alternatively, network device **250** may determine whether a connection attribute of client request **715** is identified in routing table **730**, as described in connection with FIG. **7C**.

As shown in FIG. **7C**, network device **250** may receive, from client device **210**, a client request **735**. The client request may identify a destination address (201.64.43.21), a destination port (port 80), an application signature (HTTP GET), requested content (video.vid), etc.

Network device **250** may determine whether a connection attribute of client request **735** is identified in routing table **730** (e.g., a data structure). Routing table **730** may identify one or more attributes that qualify a client request for routing to a destination address stored by routing table **730**. For example, routing table **730** may indicate that packets identifying a destination address of 201.64.43.21 and a destination port of 80 are to be routed to proxy server **240** identified by a network address of 201.64.8.100.

As shown by reference number **740**, the attributes of client request **735** (e.g., destination address 201.64.43.21 and destination port 80) match the attributes stored in routing table **730**. As a result, network device **250** may route client request **735** to a destination device identified in routing table **730** (e.g., proxy server **240** identified by IP address 201.64.8.100).

As shown in FIG. **7D**, network device **250** may receive, from client device **210**, a client request **745**. The client request may identify a destination address (201.64.99.99), a destination port (port 80), an application signature (HTTP GET), requested content (video.vid), etc.

As shown by reference number **750**, network device **250** may determine that the attributes of client request **745** (e.g., destination port 80 and application signature HTTP GET) match the attributes stored in connection attributes table **720**. Additionally, as shown by reference number **755**, network device **250** may determine that the attributes of client request **745** do not match the attributes stored in routing table **730** (e.g., destination address 201.64.43.21).

As shown by reference number **760**, based on the determinations (**750** and **755**), network device **250** may transmit a CRTP transfer request to proxy server **240**. The CRTP transfer request may identify client request **745**, connection information associated with client request **745** (e.g., destination address, destination port, application signature, etc.), requested content associated with client request **745** (e.g., video.vid), application information associated with client request **745**, etc.

As shown in FIG. **7E**, proxy server **240** may determine that client request **745** cannot be serviced by proxy server **240**. For example, proxy server **240** may determine that video.vid is not stored by proxy server **240**. As shown by reference number **765**, based on the determination that client request **745** cannot be serviced, proxy server **240** may transmit a negative response to network device **250**. Additionally, or alternatively, proxy server **240** may not respond to the CRTP transfer request within a particular amount of time, causing a timeout event to occur.

As shown by reference number **770**, if network device **250** receives a negative response from proxy server **240** and/or if the timeout event occurs, then network device **250** may route client request **745** to origin server **220** (or a device identified by a destination address associated with client request **745**, such as 201.64.99.99).

As shown in FIG. **7**F, proxy server **240** may determine that client request **745** can be serviced by proxy server **240**. For example, proxy server **240** may determine that video.vid is stored by proxy server **240**. As shown by reference number **775**, based on the determination that client request **745** can be serviced, proxy server **240** may transmit a positive response to network device **250**.

As shown by reference number **780**, network device **250** may assist in establishing a TCP connection between client device **210** and proxy server **240**. For example, proxy server **240** may establish a TCP socket (or port) to establish the TCP connection and service requests from client device **210** (e.g., client request **745**). As shown by reference number **785**, network device **250** may store connection information associated with client request **745** (e.g., a source address, a destination address, a source port, a destination port, etc.) in routing table **730** so that network device **250** may route packets associated with client request **745** to proxy server **240**.

As shown by reference number **790**, network device **250** may assist in terminating a TCP connection (e.g., established in **705**, FIG. **7**A) between client device **210** and origin server **220**. For example, network device **250** and/or proxy server **240** may transmit a TCP reset command to origin server **220**, which may cause origin server **240** to terminate the TCP connection.

The foregoing disclosure provides illustration and description, but is not intended to be exhaustive or to limit the implementations to the precise form disclosed. Modifications and variations are possible in light of the above disclosure or may be acquired from practice of the implementations.

Certain implementations have been described herein with respect to TCP. In some implementations, the techniques described herein may be used in connection with other protocols, such as user datagram protocol (UDP) and/or other protocols included in the Internet protocol suite.

As used herein, the term "component" is intended to be broadly construed as hardware, firmware, or a combination of hardware and software.

The term "packet," as used herein, may refer to a packet, a datagram, a cell, a fragment of a packet, a fragment of a datagram, a fragment of a cell, or any other type or arrangement of data that may be carried at a specified communication layer.

It will be apparent that systems and/or methods, as described herein, may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in the figures. The actual software code or specialized control hardware used to implement these systems and/or methods is not limiting of the implementations. Thus, the operation and behavior of the systems and/or methods were described without reference to the specific software code—it being understood that software and control hardware can be designed to implement the systems and/or methods based on the description herein.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the disclosure of possible implementations. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one claim, the disclosure of possible implementations includes each dependent claim in combination with every other claim in the claim set.

No element, act, or instruction used herein should be construed as critical or essential unless explicitly described as such. Also, as used herein, the articles "a" and "an" are intended to include one or more items, and may be used interchangeably with "one or more." Where only one item is intended, the term "one" or similar language is used. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A device, comprising:
one or more processors to:
receive, from a client device, a client request associated with a first TCP connection between a server device and the client device,
the client request identifying requested content;
determine connection information that identifies the first TCP connection between the server device and the client device,
the connection information including at least one of a source port number associated with the first TCP connection, a destination port number associated with the first TCP connection, a packet sequence number associated with the first TCP connection, a packet acknowledgement number associated with the first TCP connection, or a TCP window size associated with the first TCP connection;
determine whether the client request is a candidate for a TCP connection transfer based on whether the connection information is identified in a routing table accessible to the device;
generate a connection transfer request to transfer the first TCP connection from the server device to a proxy server when the client request is the candidate for the TCP connection transfer,
the connection transfer request identifying the connection information and the requested content,
the connection transfer request being different than the client request;
transmit, to the proxy server, the connection transfer request,
the connection transfer request, transmitted to the proxy server, causing the first TCP connection to be transferred by establishing a second TCP connection between the proxy server and the client device,
the second TCP connection being established based on the connection information that identifies the first TCP connection and without the proxy server sending a TCP control packet to the client device;
receive, from the proxy server, an indication that the proxy server is capable of providing the requested content;
provide, from the proxy server and to the client device via the second TCP connection, a response to the client request, based on the indication; and
provide, from the proxy server and to the server device, information that causes the server device to terminate the first TCP connection, based on the indication.

2. The device of claim **1**, where the one or more processors, when transmitting the connection transfer request, are to:

determine, based on the connection information, that the client request is associated with a connection to be transferred; and

transmit the connection transfer request based on determining that the client request is associated with the connection to be transferred.

3. The device of claim **2**, where the one or more processors, when determining that the client request is associated with the connection to be transferred, is to:

determine that the client request is associated with the connection to be transferred based on at least one of:

a port number identified by the client request;

a network address associated with the client request;

an application signature identified by the client request; or

a comparison of the connection information to information stored in the routing table.

4. The device of claim **1**, where the one or more processors are further to:

transmit a keep-alive request to a plurality of proxy servers, the keep-alive request identifying a selection algorithm to be used to select one of the plurality of proxy servers to service the client request;

receive a keep-alive response from one or more of the plurality of proxy servers,

the keep-alive response identifying status information associated with the one or more of the plurality of proxy servers, that identified status information being based on the selection algorithm;

select a particular proxy server, of the plurality of proxy servers, based on the selection algorithm and the status information; and

where the one or more processors, when transmitting the connection transfer request to the proxy server, are to:

transmit the connection transfer request to the particular proxy server.

5. The device of claim **1**, where the one or more processors are further to:

route at least one packet that assists in establishing the first TCP connection;

where the one or more processors, when transmitting the connection transfer request to the proxy server, are to:

transmit, to the proxy server, information that identifies a packet acknowledgement number or a packet sequence number associated with the at least one packet; and

where the response to the client request includes information that is based on the packet acknowledgement number or the packet sequence number.

6. The device of claim **1**, where the one or more processors are further to:

determine an amount of time that has passed since the connection transfer request was submitted to the proxy server;

determine that the amount of time satisfies a threshold that is based on a TCP retransmission timeout value; and

route the client request to the server device based on determining that the amount of time satisfies the threshold.

7. The device of claim **1**, where the information that causes the server device to terminate the first TCP connection includes information that identifies the client device.

8. A non-transitory computer-readable medium storing instructions, the instructions comprising:

one or more instructions that, when executed by a processor of a network device, cause the processor to:

receive, from a client device, a client request associated with a first TCP connection between a server device and the client device,

the client request identifying requested content;

determine connection information, associated with the client request, that identifies the first TCP connection,

the connection information including at least one of a source port number associated with the client request, a destination port number associated with the client request, a packet sequence number associated with the client request, a packet acknowledgement number associated with the client request, or a TCP window size associated with the client request;

determine whether the client request is a candidate for a TCP connection transfer based on whether the connection information is identified in a routing table accessible to the network device;

generate a connection transfer request to transfer the first TCP connection from the server device to a proxy server when the client request is the candidate for the TCP connection transfer,

the connection transfer request identifying the connection information and the requested content,

the connection transfer request being different than the client request;

transmit, to the proxy server, the connection transfer request,

the connection transfer request transmitted to the proxy server causing the first TCP connection to be transferred by establishing a second TCP connection between the proxy server and the client device,

the second TCP connection being established based on the connection information that identifies the first TCP connection and without the proxy server sending a TCP control packet to the client device;

receive, from the proxy server, an indication that the requested content is accessible by the proxy server;

route, from the proxy server and to the client device via the second TCP connection, a response to the client request, based on the indication; and

route, from the proxy server and to the server device, information that causes the server device to terminate the first TCP connection, based on the indication.

9. The non-transitory computer-readable medium of claim **8**, where the one or more instructions, that cause the processor to transmit the connection transfer request, cause the processor to:

determine, based on the connection information, that the client request is associated with a connection to be transferred; and

transmit the connection transfer request based on determining that the client request is associated with the connection to be transferred.

10. The non-transitory computer-readable medium of claim **9**, where the one or more instructions, that cause the processor to determine that the client request is associated with the connection to be transferred, cause the processor to:

determine that the client request is associated with the connection to be transferred based on at least one of:

a port number identified by the client request;

a network address associated with the client request;

an application signature identified by the client request; or

a comparison of the connection information to information stored in the routing table.

11. The non-transitory computer-readable medium of claim 8, where the one or more instructions further cause the processor to:

transmit a keep-alive request to a plurality of proxy servers, the keep-alive request identifying a selection algorithm to be used to select one of the plurality of proxy servers to service the client request;

receive a keep-alive response from one or more of the plurality of proxy servers,

the keep-alive response identifying status information associated with the one or more of the plurality of proxy servers, that identified status information being based on the selection algorithm;

select a particular proxy server, of the plurality of proxy servers, based on the selection algorithm and the status information; and

where the one or more instructions, that cause the processor to transmit the connection transfer request to the proxy server, cause the processor to:

transmit the connection transfer request to the particular proxy server.

12. The non-transitory computer-readable medium of claim 8, where the one or more instructions further cause the processor to:

route at least one packet that assists in establishing the first TCP connection;

where the one or more instructions, that cause the processor to transmit the connection transfer request to the proxy server, cause the processor to:

transmit, to the proxy server, information that identifies a packet acknowledgement number or a packet sequence number associated with the at least one packet; and

where the response to the client request includes information that is based on the packet acknowledgement number or the packet sequence number.

13. The non-transitory computer-readable medium of claim 8, where the one or more instructions further cause the processor to:

determine an amount of time that has passed since the connection transfer request was submitted to the proxy server;

determine that the amount of time satisfies a threshold that is based on a TCP retransmission timeout value; and

route the client request to the server device based on determining that the amount of time satisfies the threshold.

14. The non-transitory computer-readable medium of claim 8, where the connection information comprises at least one of:

a source network address associated with the client request;

a destination network address associated with the client request; or

an application signature associated with the client request.

15. A method, comprising:

receiving, by a network device and from a client device, a client request that identifies requested content;

determining, by the network device, connection information that identifies a first TCP connection between the client device and a server device,

the connection information including at least one of a source port number associated with the first TCP connection, a destination port number associated with the first TCP connection, a packet sequence number associated with the first TCP connection, a packet acknowledgement number associated with the first TCP connection, or a TCP window size associated with the first TCP connection;

determining, by the network device, whether the client request is a candidate for a TCP connection transfer based on whether the connection information is identified in a routing table accessible to the network device;

generating, by the network device, a connection transfer request to transfer the first TCP connection from the server device to a proxy server when the client request is the candidate for the TCP connection transfer,

the connection transfer request identifying the connection information and the requested content,

the connection transfer request being different than the client request;

transmitting, by the network device and to the proxy server, the connection transfer request,

the connection transfer request, transmitted to the proxy server, causing the first TCP connection to be transferred by establishing a second TCP connection between the proxy server and the client device,

the second TCP connection being established based on the connection information that identifies the first TCP connection and without the proxy server sending a TCP control packet to the client device;

receiving, by the network device and from the proxy server, an indication that the requested content is stored by the proxy server;

routing, by the network device and from the proxy server to the client device via the second TCP connection, a response to the client request, based on the indication; and

routing, by the network device and from the proxy server to the server device, information that causes the server device to terminate the first TCP connection, based on the indication.

16. The method of claim 15, where transmitting the connection transfer request comprises:

determining that the client request is associated with a connection to be transferred, based on at least one of:

a port number identified by the client request,

a network address associated with the client request,

an application signature identified by the client request, or

a comparison of the connection information to information stored in the routing table; and

transmitting the connection transfer request based on determining that the client request is associated with the connection to be transferred.

17. The method of claim 15, further comprising:

transmitting a keep-alive request to a plurality of proxy servers,

the keep-alive request identifying a selection algorithm to be used to select one of the plurality of proxy servers to service the client request;

receiving a keep-alive response from one or more of the plurality of proxy servers,

the keep-alive response identifying status information associated with the one or more of the plurality of proxy servers, that identified status information being based on the selection algorithm;

selecting a particular proxy server, of the plurality of proxy servers, based on the selection algorithm and the status information; and

where transmitting the connection transfer request to the proxy server comprises:

transmitting the connection transfer request to the particular proxy server.

18. The method of claim **15**, further comprising:

routing at least one packet that assists in establishing the first TCP connection;

where transmitting the connection transfer request to the proxy server comprises:

transmitting, to the proxy server, information that identifies a packet acknowledgement number or a packet sequence number associated with the at least one packet; and

where the response to the client request includes information that is based on the packet acknowledgement number or the packet sequence number.

19. The method of claim **15**, further comprising:

determining an amount of time that has passed since the connection transfer request was submitted to the proxy server;

determining that the amount of time satisfies a threshold that is based on a TCP retransmission timeout value; and

routing the client request to the server device based on determining that the amount of time satisfies the threshold.

20. The method of claim **15**, where the connection information comprises at least one of:

a source network address associated with the first TCP connection;

a destination network address associated with the first TCP connection; or

a protocol associated with the first TCP connection.

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